ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPRI109

AUTO-ALIGNMENT STATUS OF THE TAIWAN PHOTON SOURCE

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Abstract

Taiwan Photon Source (TPS) is a new 3-GeV ring under construction at NSRRC in Taiwan. There are hundreds of magnets placed on girders that must be aligned correctly to keep the electronic beam in the desire orbit. Due to the reasons of manpower, set up time, accuracy of adjustment, deformation of the floor, and limited space, an auto-alignment girder control system was designed to meet this requirement. The auto-alignment test was completed with one double-bend cell at NSRRC. The Auto-alignment process will be tested with some sections of magnet girders to confirm the control system and the algorithm in the TPS. The status and test results will be described in this paper.

INTRODUCTION

Taiwan Photon Source (TPS) is a new 3-GeV ring under construction at the NSRRC in Taiwan with the circumference of 518.4 m and 72 magnet girders. Based on the consideration of stability, the entire building was being constructed half underground at the depth of 12 m [1] [2]. The measured area was huge, causing the survey network to be difficult to be connected. During the initial constructing stage, the TPS structure and environment of the storage ring was unstable. Therefore, the auto-alignment control system was proposed to improve the precision of survey in TPS under construction.

TPS auto-alignment control system was designed for aligning the magnet girder system. The installment of instruments, calibration of sensors and experiments of one double-bend cell are finished at NSRRC. The construction of the system, calibration process, auto-alignment process, and discussion were included in the paper. Hardware includes pedestals, girders, cam movers, precision inclination sensors, laser PSD, a laser tracker and absolute length gauges. The process of auto alignment was described as follows. Rotation and transverse deviation could be measured by absolute length gauges and laser PSD. Pitch and roll angle of girders were measured by precision inclination sensors, followed by the computation of auto-alignment process with the above measurement data to update the positions of girders. Finally, girders were aligned to updated positions by cam movers accordingly. To make the experiment more accurate, all sensors and instruments have been tested during the initial stage.

STRUCTURE AND ALGORITHM

The detecting sensors of auto-alignment system are composed of absolute length gauges, laser position sensing detectors (PSD) and precision inclination sensors. There is one set of absolute length gauges between two adjacent girders and two 3-axised absolute length gauges installed at the front and end of a girder which is shown in Figure1. Four PSDs (PSD1, PSD2, PSD3 and PSD4) are installed beside the girders that can receive the laser beam separately to show the relative position between two long-distance girders which is shown in Figure2. PSD1 and PSD2 are used to align the laser beam. PSD3 and PSD4 are used to detect the relative position from PSD1 separately. Also, the aluminium tubes are installed to protect laser beam from environmental interference. One precision inclination sensor is installed on each girder to detect the tilt angle status which is shown in Figure3. All the sensors and moving systems have been checked and tested entirely including the adjustment range and cable connection test, etc. The complete test have been executed to keep the detecting and adjusting functions work allowing the TPS magnet girder system to prevent from accident damage.

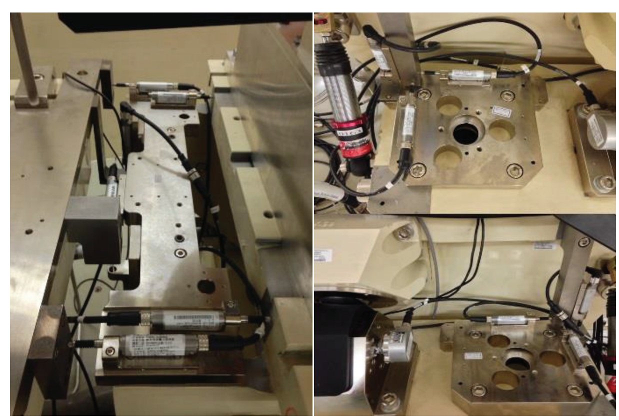

Figure 1: Absolute length gauges between two adjacent girders and two 3-axised absolute length gauges installed at the front and end of a girder.

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Figure 2: Four PSDs (PSD1, PSD2, PSD3 and PSD4) are installed beside girders respectively.

Figure 3: Precision inclination sensor is installed on each girder.

The auto-alignment algorithm is shown in Figure4. A laser tracker measures the initial position of the whole ring. All sensors of auto-alignment system provide relative positions, distance and tilt status. Following, the moving value of each girder can be also computed by the above information. The girders can be adjusted by cam movers depending on the computed moving values. There is one set of adjusting rules that we obtained during prior experiments [3][4]. It is to constrain cam movers from unreasonable moving value causing damages on the vacuum chambers and other important equipment. The rules are shown as follows. First, the transverse value must be less than 0.2 mm. Followed by the rotation value that must be less than 0.1 mrad. Third, transverse plus double rotation value must be less than 0.3 mm during 4 m. Finally, IM is the iteration moving value, where i represents i_{th} iteration cycle.

$$|dx| < 0.2 \text{ mm} \quad (1)$$

$$|d\theta| < 0.1 \text{ mrad} \quad (2)$$

$$|dx| + 2|d\theta| < 0.3 \text{ mm} \quad (3)$$

$$IM < 0.3+\sum_{i=2}^{n}\frac{0.3}{2*(i-1)} \quad (4)$$

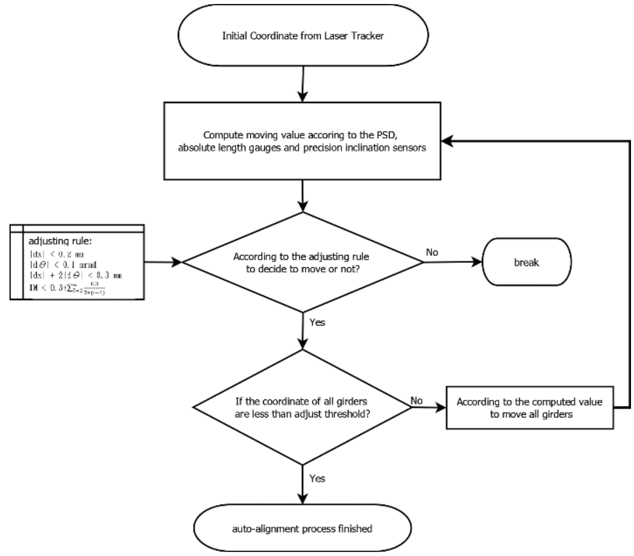

Figure 4: The flowchart of auto alignment.

EXPERIMENTS AND DISCUSSION

The temperature has been controlled within 0.4 °C during one day in the TPS. Due to the auto-alignment iteration time is estimated around one hour. PSD, absolute length gauges and precision inclination sensors have been monitored for 5000 seconds. The fluctuation of PSD1 is around 1.5 µm in transverse direction as shown in Figure 5(a). The fluctuation of PSD2 is around 1 µm in transverse direction as shown in Figure 5(b). The fluctuation of PSD3 is around 3 µm in transverse direction as shown in Figure 5(c). The fluctuation of PSD4 is around 4 µm in transverse direction as shown in Figure 5(d). The fluctuation of PSD1 will be scaled up to 3.7 and 4.5 times at the position of PSD3 and PSD4 respectively due to distance between PSDs and placement of laser source. So, the fluctuations of PSD 1 and PSD 2 must be controlled as accurate as possible.

The fluctuations of absolute length gauges are 0.3 µm and 0.5 µm in transverse and longitudinal direction. There is some interference at the last 50 seconds so that the fluctuation becomes more widely than fluctuations of earlier time. The fluctuations of precision inclination sensors are around 3 µrad in pitch and roll. According to the fluctuation of various sensors, the error range of girder position can be estimated during the auto-alignment process. In the next stage, TPS magnet girders can be aligned correctly by auto-alignment process after all PSDs are fine tuned in the TPS. Besides, the error range can be referred by auto-alignment control system and stability of detecting sensor system can also be estimated and tried to be optimized. Auto alignment will be operated and the entire ring will also be monitored by various sensors installed on the girders.

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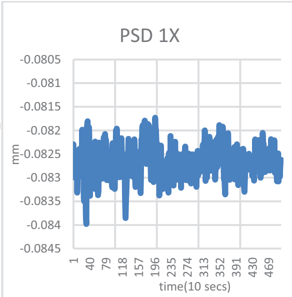

Figure 5 (a)

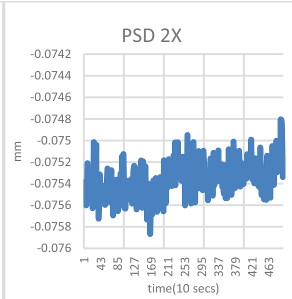

Figure 5 (b)

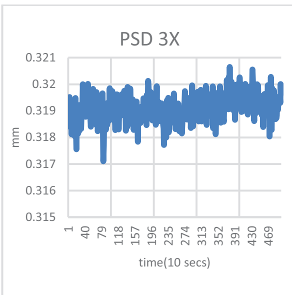

Figure 5 (c)

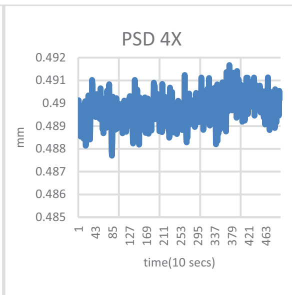

Figure 5 (d)

Figure 5 (a ~ d): are the fluctuations of PSD1, 2, 3 and 4 respectively.

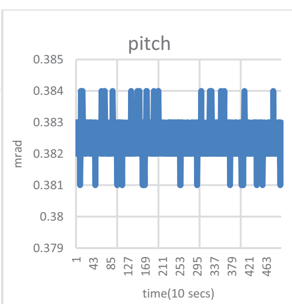

Figure 6 (a)

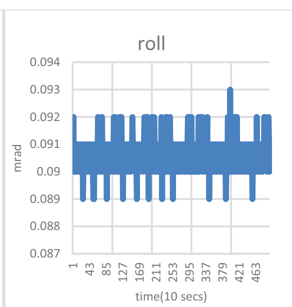

Figure 6 (b)

Figure 6 (a, b): are the fluctuations of precision inclination sensors respectively.

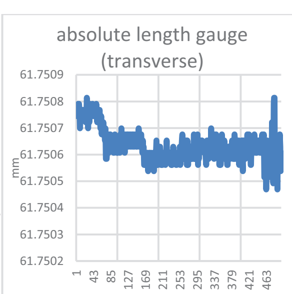

Figure 7 (a)

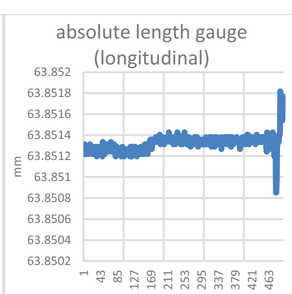

Figure 7 (b)

Figure 7 (a, b): are the fluctuations of precision inclination sensors respectively.

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